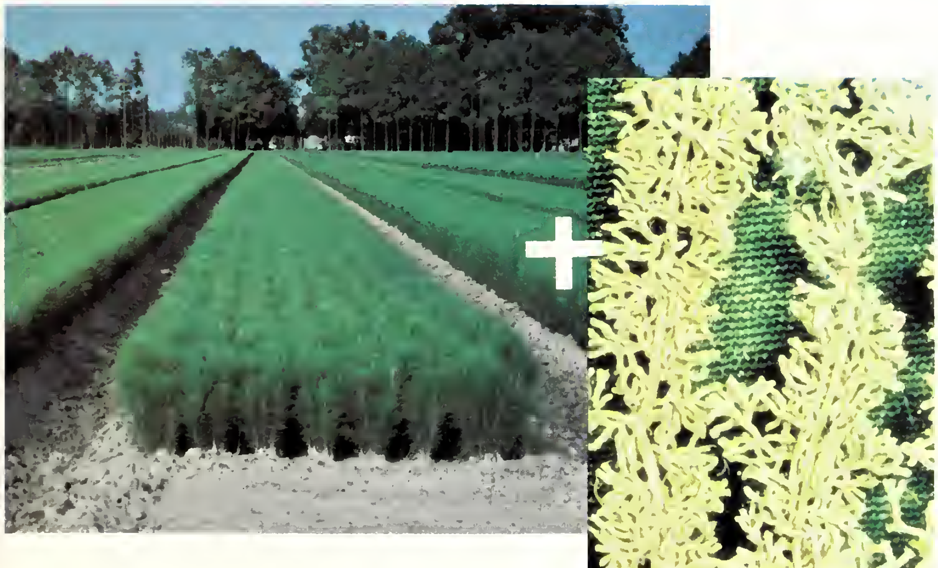
General Report SA-GR 8
July 1980

"PT"....A BENEFICIAL FUNGUS THAT GIVES YOUR TREES A BETTER START IN LIFE



+ = MORE PLANTABLE SEEDLINGS, FIELD SURVIVAL AND GROWTH

United States Department of Agriculture

Forest Service
State & Private Forestry
Southeastern Area

INTRODUCTION

Forest landowners and managers could obtain several million dollars from additional timber production with even a modest increase in the survival and growth rate of trees. Thousands of acres of seedlings die annually on field planting sites because of unfavorable weather, diseases, and other hazards. These losses can be reduced appreciably as indicated by recent tests in the laboratory, nursery, and at field sites. Although much additional research, development, and applications testing still lie ahead, forest tree nurserymen and tree farmers may begin to put the first results of this work to practical use in the next 2 to 3 years. This publication describes the first benefits expected from this work, and outlines other developments anticipated in the next few years.

Written by Charles E. Cordell and David M. Webb, respectively, National Coordinator, National Mycorrhizae Nursery Evaluation, Forest Insect and Disease Management Staff, Southeastern Area, Asheville, N.C. and Technical Publications Officer, Southeastern Area, State and Private Forestry, Atlanta, Ga.

Additional copies of this booklet are available from USDA Forest Service, Information Center, 1720 Peachtree Road, Room 816, Atlanta, Ga. 30309.

A PARTNERSHIP OF TREES AND FUNGI

Greater survival and growth of trees may be obtained by using one of nature's own partnerships — but employed more effectively and efficiently. In nature, tree seeds germinate in soil that contains fungi beneficial to tree seedlings. Some of these fungi develop a mantle or cover along with hyphae or threadlike extensions on the tree's feeder roots, increasing the uptake of water and nutrients. No harmful infection, toxin or other adverse effects are produced by the fungi.

Although some of these fungi are widespread in nature, other more beneficial ones are more limited in distribution and occurrence. In addition, certain fungi are found only with certain tree species, and other related fungi may grow best with different species of trees. Scientists have recently found how to match some of these fungi with the most suitable trees, how to produce the fungi in quantity in the laboratory, and how to use them effectively in nursery seed beds. Private industry is also learning how to best mass produce the fungi commercially. Other fungi and tree species combinations will be tested in the years ahead. Following is the story of the first of these fungi to be tested in a national program.

MYCORRHIZAE: WHAT THEY ARE

Mycorrhizae (pronounce it "my-core-rye-zee") is the term for a remarkable relationship between the feeder roots of a plant — forest trees, in this case — and beneficial fungi that live on, or in, the feeder roots. These fungi live in forest and agricultural soils in many parts of the world — their occurrence is the rule rather than the exception in nature. The relationship is mutually beneficial, for seedlings grow poorly, if at all, in soils that lack the fungi, which will not grow without their tree partners.

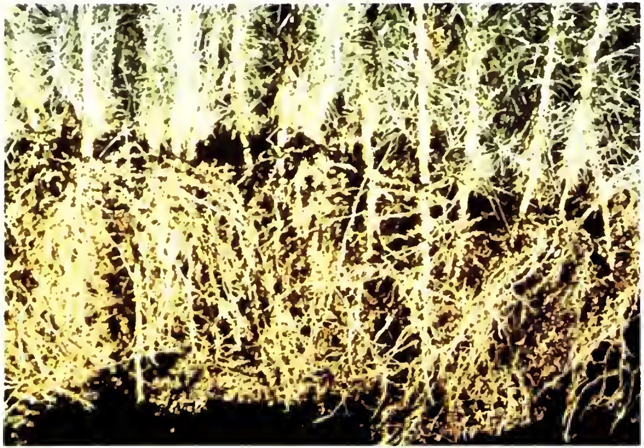
One kind develops a fungus mantle or cover along with hyphae or threadlike extensions on the surface of a tree's feeder roots. These are known as the *ecto*mycorrhizae — "ecto" meaning outside the tree root. This booklet deals mainly with a fungus that belongs to this group. For convenience, we will call this fungus PT, an abbreviation for its full scientific name: *Pisolithus tinctorius*.

PT develops ectomycorrhizae on the roots of pine species such as loblolly, sand, slash, Virginia, shortleaf, longleaf, red, Austrian, scotch, ponderosa and eastern white pine. Other good associates for PT are Fraser fir, Douglas-fir, and some species of spruce and hemlock. PT also forms a beneficial association with several species of hardwoods: several species of oaks, birches, eucalyptus, and American chestnut.

PT and its relatives in the ectomycorrhizae

clan live underground, but the fungus fruits above ground at certain times of the year. PT forms a puffball, while some of its relatives form a more conventional-looking mushroom. The puffballs and mushrooms produce fungus spores that are windborne to new locations and eventually come in contact with the feeder roots of trees — a seemingly haphazard, natural process that nevertheless assures the continued survival of the fungus.

A second group of the mycorrhizae family, less conspicuous but even more abundant in nature, is just as important as the ectomycorrhizae. These are the *endo*mycorrhizae, which are not at all like the ectomycorrhizae, but perform the same function *within* a tree's roots. They are important fungal associates for many of the hardwoods and some conifers. Later, work will also be done on ways to use them more effectively and efficiently in forest tree nurseries and reforestation. However, because of the ease with which it can be grown in the laboratory, more practical progress has been made with PT. PT can be produced in an artificial growth medium in the absence of a host plant — and in quantity — unlike the endomycorrhizae, which require a living host for growth, reproduction, and survival. Therefore, the remainder of this booklet will deal with PT and its potential usefulness in forestry.



PT's conspicuous, branching, fungus mantle and strands extend into the soil to serve as an expansion of a tree's roots. PT may also provide other benefits, such as protecting the roots from harmful fungi. Tree seedlings having feeder roots that do not have a PT fungus mantle or root cover are shown above, at the right. Their sparse feeder root system may not enable them to survive and grow as vigorously as seedlings with the PT ectomycorrhizae fungus mantle (at left) that more effectively absorb water and nutrients.

Ectomycorrhizal roots absorb moisture and nutrients from the soil more efficiently than do similar roots that either lack, or are deficient in, ectomycorrhizae. This added benefit to tree seedlings, for example, may often mean the difference between life and death on adverse planting sites. PT ectomycorrhizae on the feeder roots of most southern pines have been

repeatedly demonstrated to ensure greater survival and growth of tree seedlings in field outplantings.

How long do the PT ectomycorrhizae benefit a tree? The final answer awaits future field outplanting results, but even if PT's recently demonstrated benefits to 5-year-old outplantings are temporary, the early seedling survival and growth will be highly beneficial to tree farmers and forest tree nurserymen.

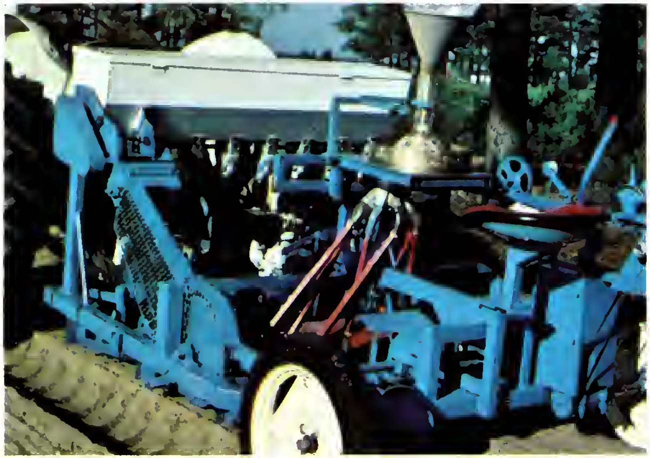
You are most likely to find a fruiting body or puffball of PT when it's time for the fungus to reproduce. The PT puffball grows on the surface of the ground and produces fungus spores that are spread by the wind (photo at right). Scientists and field foresters are trying to give nature a helping hand to assure a more effective and efficient means to use PT — and to distribute it where it's needed most, as you will see on the following pages. Most ectomycorrhizal fungi and their tree hosts are not well adapted to the more severe reforestation sites, but PT is able to grow and reproduce even on adverse mine spoil and kaolin clay sites. Intensive planting site preparation also frequently results in hot, dry, exposed soils, but PT does well even under these unfavorable conditions.

HOW PT IS USED

The first step is to fumigate nursery seedbeds, then inoculate the soil with PT before planting. The most effective fumigants have been formulations of either (1) a mixture made up of 98 percent methyl bromide and 2 percent chloropicrin, or (2) a mixture made up of 67 percent methyl bromide and 33 percent chloropicrin. Consult Federal or State pest control specialists for specific guidelines and precautions required for methyl bromide nursery seedbed fumigation in conjunction with PT mycorrhizae inoculations. For example, extended soil aeration (at least 3 weeks) is required when using the 67 percent methyl bromide — 33 percent chloropicrin formulations before inoculating with PT.

PT obtained from small, highly-controlled cultures in the laboratory, or from a bulk inoculum produced by a pharmaceutical company, is spread on a nursery seedbed. A predetermined quantity is used for maximum effective and efficient formation of ectomycorrhizae on the seedlings that will be produced.

PT is mixed in the soil to a depth of 3 to 4 inches (7.6 to 10 cm) to contact the developing feeder roots of the seedlings. In nature, the majority of the PT spores probably never come in contact with a seedling's feeder roots because of its haphazard means of spreading. Plans are being made to develop and field test equipment to apply PT at the same time tree seeds are planted, by modifying existing commercial tree seeding or mulching equipment. If effective, this procedure will reduce the amount of PT needed to accomplish the same results now obtained by surface broadcast inoculation.



One of the most practical application methods in bareroot nurseries involves the use of a PT inoculum applicator-tree seeder, as shown above. Although PT has been and, most likely, will continue to be applied in the nursery rather than at the forest planting site, seedlings benefit at both locations.

In 1977, PT-treated plots in 16 widely distributed forest tree nurseries from Virginia to California produced 32 percent fewer seedling culls than did untreated plots. Seedlings grown in the same PT-treated plots also had 14 percent more fresh weight than those in untreated plots.

In 1978, PT-treated plots in 12 nurseries in the South and central United States produced 26 percent fewer seedling culls with an increase of 26 percent in seedling fresh weight, as compared with untreated plots.

Although these nursery results are highly beneficial, the major benefit comes with the subsequent outplantings of these seedlings. Their increased quality in terms of a sturdy ectomycorrhizal root mass, as well as vigorous, healthy tops, gives the PT-treated seedlings much better odds for survival and growth when planted on a variety of reforestation sites.

BENEFITS OF MYCORRHIZAE

Although the differences in size and quality are readily apparent, the tree seedlings shown here are the same age. The vigorous, ectomycorrhizal feeder roots of the loblolly pines (left) provide an advantage that results in superior quality when compared with the seedlings that lacked PT on their feeder roots (right). Feeder roots take in most of the water and nutrients required by the tree, making PT a very important component of these roots. Also, seedling root/shoot ratios are considerably more balanced on seedlings with abundant ectomycorrhizae than on those without.

NURSERY

Nursery losses of plantable-seedlings at lifting time are a major concern to nurserymen. PT and other ectomycorrhizal fungi help resolve this problem. As stated before, PT-treated plots in 1977 and 1978 had 32 and 26 percent fewer seedling culls, respectively. In these tests, the PT treatments resulted in a 7 percent overall increase in plantable seedlings — potentially worth $847,000 in added annual nursery seedlings values in the South alone.

FORESTATION

PT-treated loblolly pine.

Untreated loblolly pine.

Significantly increased growth of trees from nursery plots treated with PT is amply demonstrated above and on the next page. Loblolly and eastern white pine, 5 years old, outperformed untreated (check) seedlings of the same age and species. Additional outplanting tests are being made throughout the United States. PT also has a widespread host range that includes the majority of the most important coniferous trees throughout the United States.

PT-treated eastern white pine.

Untreated eastern white pine.

PT tolerates high temperatures, droughty soils, and both acid and alkaline soils. Results from 5-year-old outplantings in North Carolina show some routine reforestation sites may achieve a 25-percent or higher increase in wood volume production. Even a 10-percent increase would represent a potential annual gain of 4 million cords of pulpwood in the South alone, worth $75 million at today's stumpage prices.

WHERE DO WE GO FROM HERE?

By 1980, the potential commercial production of PT by a major pharmaceutical company could expand the availability of the fungus to most nurseries. At the same time, and in following years, more refinements will be made in application rates and methods. More "tailored" tree seedlings may become available from PT-treated nursery beds. The process parallels the development of genetically superior trees. At first, the "super" trees were available in very small numbers. Today, one half or more of most southern pine nursery stock consists of genetically improved tree seedlings, with the proportion increasing every year.

Some of PT's fungus relatives may also be tested on other tree species — both conifers and hardwoods. They may also be commercially available as practical production and applications develop. Someday, garden supply stores may even offer a PT product and its relatives for individual home use. The future commercial production of PT, as with many other new products, will depend mainly on consumer demand (forest trees nurseries) and on economic conditions. The product can, and will, be successfully produced — if there is adequate demand for it in the nurseries.

THE ROLE OF YOUR STATE FORESTRY AGENCY AND THE USDA'S FOREST SERVICE

State, Federal, and industry nurseries are testing PT and other related mycorrhizal fungi in all parts of the United States. Seedlings with PT ectomycorrhizae may first become available to private forest landowners through their State forestry agency. The nurseries should be able to produce "tailored" seedlings to meet individual needs. If you have adverse planting sites, you may get first choice of the PT seedlings. As seedlings with PT become more available, they may be distributed more widely. Additional species may also be available from PT plots. Eventually, your State forestry agency may produce several species of seedlings that contain other kinds of ectomycorrhizae. Mycorrhizae developments and applications may continue to expand in future years.

This application program is based on research results obtained by the Mycorrhizal Institute, Southeastern Forest Experiment Station, Athens, Ga. Cooperating agencies include the Southeastern Area of State and Private Forestry, other units of the Forest Service, several State forestry agencies, industries, and universities.